

II.4-LAY-COEF LAYERED COEFFICIENT ROUTING

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Introduction

Layered coefficient routing is a routing method that attenuates discharge in a reach by applying different routing coefficients to different levels of flow.

Burnash, Ferral and McGuire (1973) relate this method of routing to a layered Muskingum concept. In practice it resembles Tatum coefficient routing. Layered coefficient routing is particularly suited for reaches that have nonlinear storage-flow relationships. The number and thickness of discharge layers as well as the selection of an appropriate coefficient for each layer must be determined from historical records. These details should be based on physical or storage characteristics of the reach as much as possible. For example one routing coefficient might be used to route all flows that remain within banks. A second coefficient may then be used to route that portion of the flow which overtops the banks. Such a two-layer system would permit both within-banks and over-bank storage-flow relationships to be accounted for.

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Procedure

The layered coefficient Operation takes instantaneous inflow to a reach at a specific ordinate and separates the flow into one or more flow components corresponding to the discharge layers. The outflow or routed flow for each layer is determined by multiplying the flow component by the appropriate coefficient. The residual flow left over after this multiplication is carried over and added to the flow component for that layer at the next ordinate. The layered coefficient routing equation can be expressed as:

$$O_{t\ell} = c_{\ell} * (I_{t\ell} + R_{(t-1)\ell}) \quad (1)$$

where $O_{t\ell}$ is instantaneous outflow for layer ℓ at time t
 c_{ℓ} is the routing coefficient for layer ℓ
 $I_{t\ell}$ is that portion of instantaneous inflow appropriate for layer ℓ
 $R_{(t-1)\ell}$ is the residual flow in layer ℓ from the previous routing period

$$R_{t\ell} = (I_{t\ell} + R_{(t-1)\ell}) - O_{t\ell} \quad (2)$$

Instantaneous outflow is found by summing the routed flow of all layers. Mathematically this is expressed as:

$$O_t = \sum_{\ell=1}^L O_{t\ell} \quad (3)$$

where L is the number of layers

Table 1 presents a tabular example of layered coefficient routing applied to channel reach AB. Three discharge layers have been determined for the reach. Using Q to indicate discharge the coefficients for the reach are:

Layer	Coefficient	For
1	0.8	$Q \leq 200$ CMS
2	0.6	$200 \text{ CMS} < Q \leq 400$ CMS
3	0.4	$Q > 400$ CMS

Flows in Table 1 [Bookmark] have been rounded to one decimal place. Note that the flow component within a layer equals the appropriate instantaneous inflow for the layer, plus the residual flow carried over from the previous ordinate. Routing in this manner is similar to applying a decay function to flow. As inflow falls back into the range of Layer 1 during the recession the residuals in the upper layers become smaller and smaller but never reach 0.0. Mathematically, this would continue infinitely. To avoid the continued routing of small residual flows the residuals are set to 0.0 when they become less than 0.00001 CMS. Figure 1 [Bookmark] illustrates the amount of attenuation produced by routing with these coefficients.

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Comments on the Use of Layered Coefficient Routing

There are no specific limits to the number of layers or to the width of layers. These details must be determined by the user.

The layered coefficient routing procedure does not contain any provision for applying lag to inflow. However lag can be applied by using the lag algorithm prior to routing with layered coefficients.

Layered coefficient routing has the ability to variably attenuate flow in a reach because of different coefficients for different layers of flow. Therefore this method can be used at a point to account for attenuation in a channel system above a headwater gage.

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References

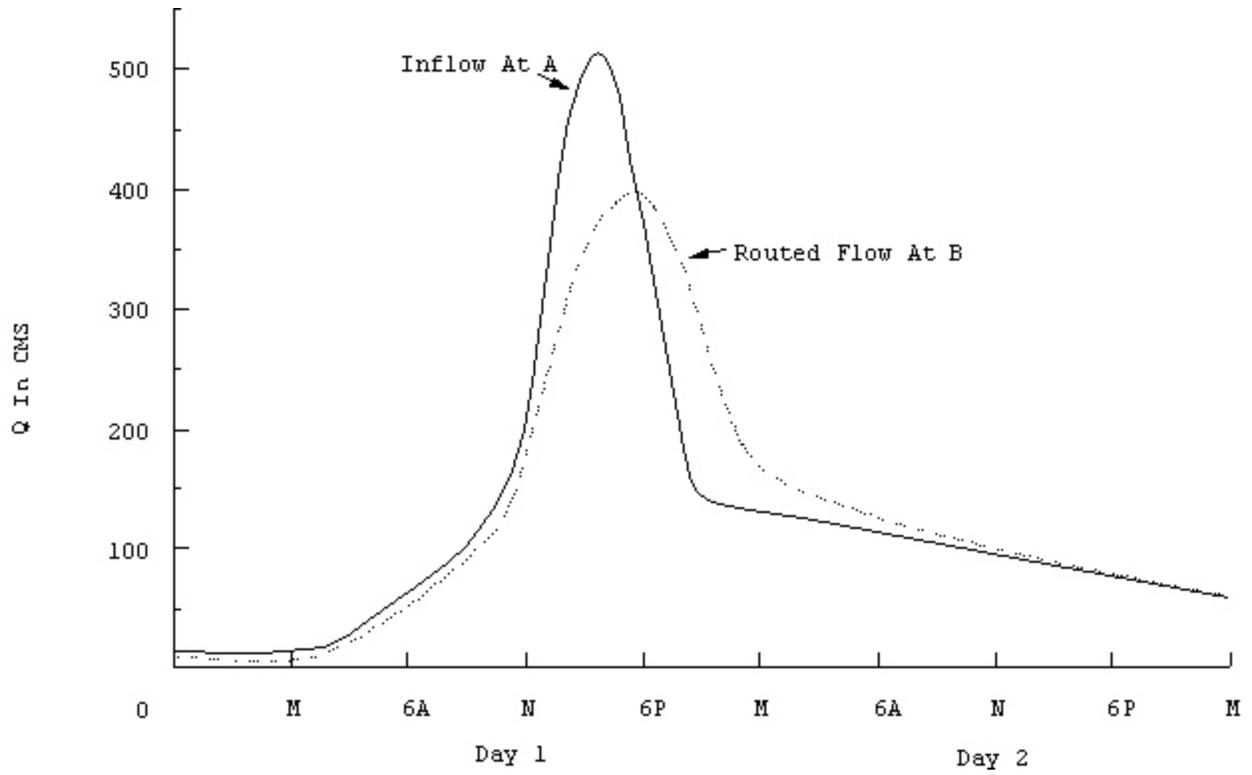
Burnash, R.J.C., Ferral, R.L. and McGuire, R.A., 1973: 'A Generalized Streamflow Simulation System', Joint Federal-State River Forecast Center, Sacramento, California.

Table 1. Tabular example of Layered Coefficient Routing

Routing Period	Inflow at A CMS	Layer 1 Coefficient = 0.8			Layer 2 Coefficient = 0.6			Layer 3 Coefficient = 0.4			Outflow at B CMS	
		Flow	Routed	Residual	Flow	Routed	Residual	Flow	Routed	Residual		
DAY 1	12 M	17.3	21.1*	16.9							16.9	
	3 AM	23.2	27.4	21.9							21.9	
	6 AM	66.0	71.5	57.2							57.2	
	9 AM	125.0	139.3	111.4							111.4	
	12 N	337.0	227.9	182.3	45.6	137.0	82.2	54.8				264.5
	3 PM	511.0	245.6	196.5	49.1	254.8	152.9	101.9	111.0	44.4	66.6	393.8
	6 PM	331.0	249.1	199.3	49.8	232.9	139.7	93.2	66.6	26.6	40.0	365.6
	9 PM	151.0	200.8	160.6	40.2	93.2	55.9	37.3	40.0	16.0	24.0	232.5
	12 M	124.0	164.2	131.4	32.8	37.3	22.4	14.9	24.0	9.6	14.4	163.4
DAY 2	3 AM	106.0	138.8	111.1	27.8	14.9	9.0	5.9	14.4	5.8	8.6	125.9
	6 AM	91.9	119.7	95.8	23.9	5.9	3.5	2.4	8.6	3.4	5.2	102.7
	9 AM	85.4	109.3	87.4	21.9	2.4	1.4	1.0	5.2	2.1	3.1	90.9
	12 N	75.7	97.6	78.1	19.5	1.0	0.6	0.4	3.1	1.2	1.9	79.9
	3 PM	68.9	88.4	70.7	17.7	0.4	0.2	0.2	1.9	0.8	1.1	71.7
	6 PM	61.7	79.4	63.5	15.9	0.2	0.1	0.1	1.1	0.4	0.7	64.0
	9 PM	55.1	71.0	56.8	14.2				0.7	0.3	0.4	57.1
	12 M	49.7	63.9	51.1	12.8				0.4	0.2	0.2	51.3

* The initial midnight flow in Layer 1 includes a residual carryover from the previous ordinate.

Figure 1. Example of Layered Coefficient Routing



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